The Perception of Urban Dwellers on the Impact of Brickfields' Smoke Emissions on Socioeconomic Conditions and Human Health: A Case Study of Pabna, Bangladesh

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Article information	Abstract
History Received 12/09/2022 Accepted 26/09/2022 Published 05/10/2022 **Keywords** Brickfield, Smoke emission, Air pollution, Human health, Environment, Pabna city. Copyright © 2022The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution ShareAlike 4.0 International (CC BY-SA 4.0)	The use of bricks in construction work is increasing in Bangladesh is increasing day by day. Pabna is a growing city with a large population. As a result, numerous brick fields have been established in Pabna Municipality and the adjacent areas. As a result, brickfield smoke emissions are increasing daily. Various socio-economic, environmental, and health-related issues have emerged. However, no initiatives were taken to preserve the air quality of Pabna. In Pabna, Bangladesh, the research looks into the effects of Brickfields' smoke emissions on socioeconomic circumstances and human health. This study determines which diseases are caused by air pollution, as well as the social and economic effects of the brickfields on Pabna municipality. In addition, the air quality index (AQI) has been determined by the study. This research was utilized to spur the development of future studies aimed at reducing and controlling the air pollution concerns related to brickfields in this area. It is also anticipated that the survey would help develop future control strategies for creating a pollution-free environment in Pabna, Bangladesh. The influence of brickfield-related smoke on human health and socioeconomic situations will be investigated in this study. Finally, the research will give suggestions based on stakeholder input to assist authorities in developing a viable, long-term strategy for the future.

1. Introduction

Brick is a synthetic stone made of clay whose dominant traits are plasticity while wet and stone-like hardness after being heated to an excessive temperature (Aziz, 1981). Bangladesh's population growth and growing affluence have contributed to multiplied creation and a call for building materials (BBS, 2012). In Bangladesh, clay bricks are drastically used as construction materials. Speedy urbanization inside the country consumed the brick production of eight billion every 12 months. More significantly, brickfields were set up illicitly close to human homes, faculties, schools, and medical service workplaces (Abir, 2019). Brick industries are growing unexpectedly in Bangladesh, India, and the penal sector, where more than 108,000 brick kilns are in operation (Pariyar et al., 2013). There are approximately 6000 brick producers in Bangladesh, which produce about 18 billion pieces of brick a year (Rahman, 2012). Brick burning contributes to environmental contamination, ecosystem mutilation, and greenhouse gas concentration in the atmosphere to a greater extent (Kumar et al., 2020). The more significant parts of the brick kilns in Bangladesh are inadequately planned, which causes the fragmented burning of coals (Ahmed, 2007). This defective burning produces carbon monoxide (CO), which increases the hazard of heart sickness. On the off chance that elastic tires are utilized as fuel, discharge from block furnaces contains fine residue particles, hydrocarbons, sulfur dioxide (SO_2), oxides of nitrogen (NO_x), fluoride mixtures, and a modest quantity of cancer-causing dioxins (Jerin et al., 2017). This smoke, created by the brickfields, causes a considerable amount of severe damage to human health. Moreover, due to brickfields, an enormous number of trees are chopped down, causing critical deforestation. Besides, because of air pollution caused by brickfields, average agricultural production is being hampered. The average social life of human beings is hampered. This is where the inspiration for doing the study has come. This study will examine

how brickfield-related smoke affects human health and socio-economic conditions and the relationship between the impact of brickfield smoke emissions and socio-economic conditions, along with human health. A total of 384 (Sample size, n = 384) stakeholders from the fifteen wards were surveyed to determine the impact of brickfield-related smoke on human health and socioeconomic status. Almost all of the words are emitted by brick smoke. A major study gap is that most of the research regarding brick field emission has been done mainly on divisional frills. Districts like Pabna have always been ignored and no work has been done on brickfield emissions. Moreover, the project will help policymakers make better policies regarding brickfields in the future. The study will determine the impact of Brickfields' smoke emissions on socio-economic conditions and human health in Pabna, Bangladesh. This will find out what specific diseases are held because of air pollution and the social and economic impact on Pabna municipality due to the brickfields. In addition, the air quality index (AQI) will be determined by the study. This work could be used as an incentive to perform other studies to develop strategies that would control and diminish the air pollution problems associated with brickfields in this region. It is also anticipated that the survey would help develop future control strategies for creating a pollution-free environment in Pabna, Bangladesh. Through this project, the impact of brickfield-related smoke on human health and socio-economic conditions will be assessed. Finally, the study will provide recommendations with stakeholder participation to help the authorities make a fruitful, sustainable plan for the upcoming days. Almost all the research on air quality impacts in Pabna municipality was done based on transportation emissions. Furthermore, the Pabna MIDP (Municipal Integrated Development Plan) makes no mention of brickfield emissions. Additionally, no work was done on people's perceptions of the impact of brickfield emissions in Pabna municipality. This study will address this problem and determine the effect of brickfield-related smoke on human health and socio-economic conditions based on people's perceptions. A participatory-based vulnerability investigation involves the affected individuals in identifying issues and needs, developing solutions for them, carrying out agreed-upon exercises to achieve those arrangements, and assessing the outcomes. The method's advantages are the development of limits and the debacle of production hazards, the board perspectives, conduct, and more substantial knowledge of the networks, empowering better outcomes. Participatory investigation might be more financially savvy in the long haul than remotely determined activities, because they are bound to be feasible and because the cycle permits thoughts to be tried and refined before selection. This study will help the policymakers to understand the threat of brick field emission and degradation of air quality of Pabna and provide sustainable solutions.

2. Literature Review

An Air Quality Index (AQI) is a way to portray encompassing air quality in comparison with the essential public air quality principles. It aids in notifying sensitive populations that they should take appropriate measures to lessen their openness to the surrounding air and informing the general population that there are genuine issues with air quality that should be addressed as a cultural duty to the entire populace. People in different countries use different tones and assign different characteristics to the same word for expected danger (Hasan et al., 2016). Illegal and technologically backdated brick kilns are responsible for more than half of the pollution in this area. As a result, both human and environmental health may be jeopardized. Rapid urbanization, a rise in the number of automobiles in Dhaka and other cities throughout the nation, the usage of fossil fuels, and industrial emissions are all contributing to severe pollution (Qiu et al., 2021). In Bangladesh, it is estimated that block ovens emit PM 2.5 (particulate matter), which is considered more harmful to human health because it can travel deeper into the respiratory framework and cause premature mortality and respiratory illnesses (Guttikunda, 2009). Senior citizens and children are essentially more vulnerable to these PMs than any other age group because our disease prevention instruments become more vulnerable (Environmental Protection Agency, 2015). (Jerin et al., 2018) aimed to uncover changes in financial and natural angles that the respondents saw when building brickfields around them. Data was needed to show whether the block fields had a positive or negative effect on agribusiness, hydroponics, and the financial state of the area they were looking at. This is what the study looked at. Various kinds of hazardous substances, such as sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NO_x), and suspended particulate matter (SPM), are emitted throughout the brick manufacturing process, ranging from soil excavation to brick transportation. According to Zeeshanet et al., (2016), the brick kiln sector has a key role in the development of respiratory disorders. When exposed employees were compared to control workers, there was a substantially greater incidence of chronic cough (31.8%), and this elevated symptom frequency was also found among non-smokers evaluated by age and duration of employment. Groneberg et al. (2006) ended their research by stating that several respiratory disorders such as cough, sputum, wheezing, and dyspnea were more prevalent among employees who worked near kilns. Acute SO2 exposure causes bronchial constriction, increased pulmonary resistance, and increased airway responsiveness, among other things (WHO, 1979; Amdur, (1978). Short-term exposures to ambient

concentrations exceeding 1,000 g/m3 (acute exposures estimated over 10 minutes) tend to have the greatest health consequences. World Bank Group, (1998).

Table 1: Emission types and sources of a brick kiln.

| Processes	Probable Pollutants Emission	Reasoning
Soil Excavation and Clay Preparation	PM, CO2, CO, SOx and NOx	Combustion of fuels and electricity, soil excavation, and clay preparation (Rajarathnam et al 2014).
Manual Molding, Sun Drying, Loading, and unloading Kiln	SPM	Most brick kilns are used to complete these processes manually by workers (Skinder et al. 2014).
Firing and Transport	PM, CO2, CO, SOx and NOx etc.	Firing green bricks and transporting them to other required places emit maximum because of combustion of fuels during transport and the burning of Coal/Firewood/ Rice Husk.
Cooling	None	Does not require any energy.

Source: (Maheshwari, H., Jain, K., 2017)

Fine particles are those with a particle size of fewer than 2.5 microns and have a negative impact on the lungs (Nasir, 2016). Long-term exposure to urban air pollution has been linked to a reduction in lung function and a shorter life span in humans (Costa and Amdur, 1996; Heyder and Takenaka, 1996). Sulfur dioxide in the air has been linked to a decrease in lung function and more respiratory symptoms and illnesses (Skinder, 2014).

3. Materials And Methods

3.1 Study area profile

Pabna municipality was one of the oldest cities in Bangladesh and it was established in 1876 (Figure-1). In 1868, Pabna Town Committee was set up before the Pabna Municipality foundation. Pabna district was moved up to the 'A' Category region in 1989 (Parvez, Sadat, Tasnim, & Nejhum, 2021). It is situated 161 km Northwest of Dhaka city and 110 km East of Rajshahi city. The zone of the district is around 16 km^2 with a populace of 133403. The zone is dispersed between 23º53" N and 24º 05" N Latitude and 89º 09"E and 89º 25" E longitudes. There are 15 wards comprised of the Pabna Municipality (Parvez and Islam, 2020). It is bounded by Shalgaria and Laskorpur beyond the river Ichamoti on the North, Dakshin Ramchandrapur on the South, Arifpur-Mahendrapur-Madarbaria on the East, and Hemayetpur and Pailanpur on the West part of the Paurashava. Pabna Paurashava is a land of mixed topography. The Ichamoti River is passing through the middle of the municipality in the north-south direction. But presently this river is in dead condition. The Ichamoti river is filled with water weeds and siltation. The river lost its navigation during the long years (Parvez & Rana, 2021).
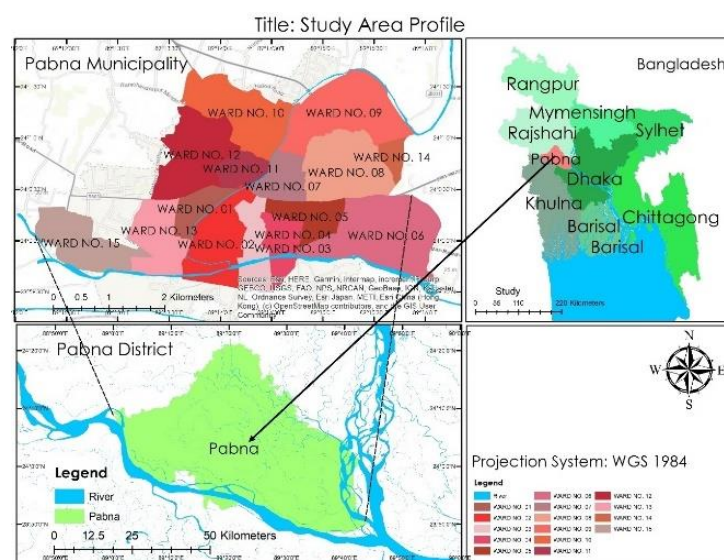
Source: Author, 2021

Figure 1: Study Area Profile

3.2 Data (NO_2 and O_3) Pollutant Data

The Tropospheric Monitoring Instrument (TROPOMI) on the Sentinel-5 Precursor satellite (also known as Sentinel-5P) was used to evaluate the spatiotemporal development of tropospheric NO_2 and the total ozone column (O_3). The TROPOMI is a nadir-viewing hyperspectral imager that is passive (Veefkind et al., 2012). Sentinel-5P is a near-polar solar synchronous satellite orbiting at an altitude of 817 km in an ascending node with an equatorial crossing time of 13:30 LT and a repetition period of 17 days. The product was acquired using the Level 2 Sentinel-5P TROPOMI-based tropospheric NO_2 and O_3 at 1-Orbit with a resolution of 7 3.5 km (5.5 3.5 km since 30 April 2018). Scenes with a cloud percentage > 0.5 and other scenes marked with mistakes or troublesome retrieval were disqualified, and only those measurements with a data quality value of QA > 0.75 were evaluated (Ialongo et al., 2020).

3.3 Existing Brick field status

In Pabna Municipality and Surroundings area, 21 brickfields are present according to MIDP. Moreover, several brick fields are present surrounding Pabna Municipality. Shafique Auto Bricks, AM Auto Bricks Ltd, HKB Bricks Pabna Bricks, Sony Bricks, Pony Bricks, MAB Bricks, and KSB Bricks are some renowned brickfields of Pabna. Most brickfields are situated mainly in Ward no 4, Word no 3, and Word no 6. Among the five stations of the study from where the number of different types of particulates is being carried out, three wards are mainly situated at Library Bazar and Ononto Mor.
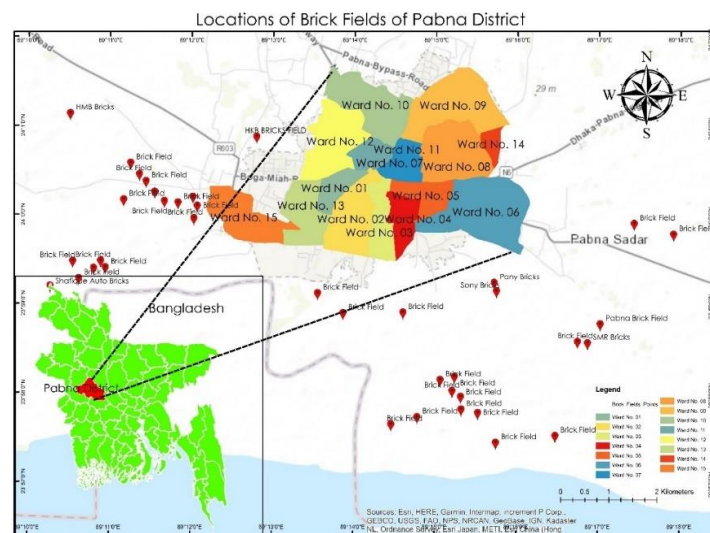

Figure 2: Location of Brickfields of Pabna Districts

3.4 Methods

To fulfill the objective of the study, the whole study has been conducted following an orderly systematic process. Both primary and secondary data were used for conducting the study. Both National and International journals, books, and papers regarding satisfaction assessment of public transport were studied. For determining the sample size, the following Cochran equation is used

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where,

Where n is the sample size, Z is the value of the standard normal deviate at a 95% confidence level (1.96), p is the sample proportion, q is equal to $(1 - p)$, and e is the acceptable margin of error (0.05) and N is the number of population (Kobra *et al.,* 2018). Here the total number of populations of Pabna Municipality is 168125, So the N=168125. The sample proportion p is 0.5. So, from the equation, the sample size is determined as n=384.

Some data will be collected from the National Ambient Air Quality Monitoring program. Besides, the impact of smoke and air pollution originating from the brickfields will be identified from the field survey and the data will be analyzed by the logistic regression model. Moreover, the impact on socio-economic conditions will be carried out through Pearson's correlation model and regression model. Five variables (Solid waste disposal into the

drainage, Absence of operation and maintenance system, small discharge capacity with blocked in the current drains, Non-Appearance of combined drainage network of roadside drains, and Unplanned drainage system) were determined with the help of a reconnaissance survey and previous studies e.g., MIDP, journals or reports. A five-point Likert scale ranging from "1" = Severe problematic, "2" = problematic, "3" =Moderate, "4" = Not problematic, and "5" = Not Severe problematic, was used to find out the respondent's satisfaction Scenario. The overall perception of the respondent was calculated based on a mean score of all five variable values. For collecting the impact level of the vulnerable data, a questionnaire survey was conducted in 15 wards of Pabna municipality.

The questionnaire asked about the five variables along with socio-economic information, age, occupation, gender, and employment. The data collected from the questionnaire survey was recorded in SPSS. The data was analyzed by Correlation and Regression methods. To find out the relationship between the dependent variable and independent variables is explicated through the following equation.

$$Y = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \ldots\ldots + \beta iXi$$

Here, Y is the dependent variable, α is the constant, βi (i= 0, 1, 2, 3……, n) is the regression coefficients, Xi (i= 0, 1, 2, 3……, n) is the independent variables, and n is the number of the independent variable. These methods help to predict the perception level of the consumer on waterlogging. Some relevant proposals have also been suggested based on the outcome of the questionnaire survey.
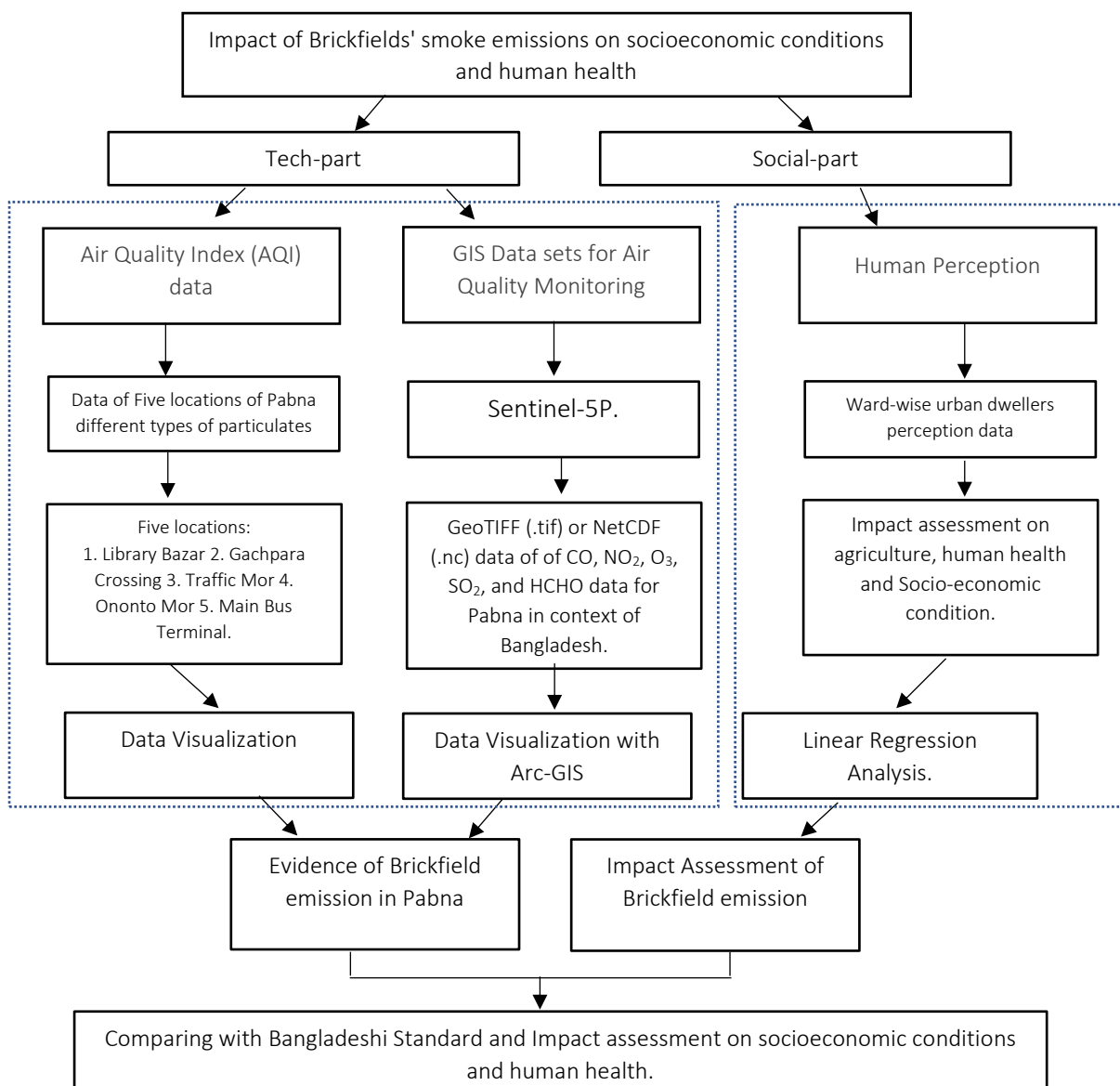

Figure 3: Methodological Framework of the Study

4. Results and Discussions

4.1 Existing Air Quality

It is widely accepted that particulate matter is the major pollutant of concern internationally and in Bangladesh (ADB 2006, UNEP 2012). A particulate matter is defined as a solid or liquid particle suspended in a gas, which is usually air. Particulate matter is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets (Akhter, 1999). In the term project, the Air Quality Index (AQI) will be used. Secondary data on AQI will be collected from the department of Civil Engineering, Pabna University of Science and Technology (PUST). The data collected from Particulate matter sampling was performed by using the device "Handheld Laser Particle Counter" to collect the data from five different locations. To bring accuracy in our measurement and for comfort handling of the particle counter "Repeat Mode" is found suitable for our work. Thus, we have selected the "Repeat Mode" and collected the data for our work. By setting the sampling time, frequency, and interval of each measurement, this unit automatically measures as specified and stops after the measurements. Interval is the time between the beginning of the first measurement and the next. In this method, particle size can be set. The device was placed in the selected locations for collecting PM from morning to evening (9:00 a.m. to 5:00 p.m. local time). In this work, it has been tried to find out the particulate matter (PM) has an aerodynamic diameter of 0.3, 0.5, 1, 3, 5 µm and the vehicles passing through those points per 30 minutes to determine in which area the particulate matter is higher when the vehicle passing rate is high (Hasan *et al.*, 2016). In addition, the air quality model is available from the U.S. EPA's Support Center for Regulatory Air Models (SCRAM) (EPA, 2011). Particulate matter is primarily formed from chemical reactions in the atmosphere and through fuel combustion with insufficient oxygen e.g., motor vehicles, brickfields, power generation, industrial facilities, residential fireplaces, wood stoves, and agricultural burning.

Table 2: Ambient air quality standards in Bangladesh and their comparison with WHO and US standards

Pollutant	Averaging time	Bangladesh Standard ($\mu g/m^3$)	WHO standard ($\mu g/m^3$)	US Standard ($\mu g/m^3$)
PM 2.5	24 hr	65	25	15.4
	Annual	15	10	-
PM10	24 hr	150	-	54
	Annual	50	20	-
Ozone (O_3)	8 hr	157 (0.08 ppm)	100	25
	1 hr	235 (0.12 ppm)	-	-
Carbon Monoxide (CO)	8 hr	10,000 (9 ppm)	10,000	3.8
	1 hr	40,000 (35 ppm)	30,000	-
Sulfur Dioxide (SO_2)	1 hr	80 (0.03 ppm)	-	13.4
	24 hr	365 (0.14 ppm)	20	-
NO_2	1 hr	100 (0.053 ppm)	-	28.2

Source: Country Synthesis Report on Urban Air Quality Management, 2006

Table 3: Classification of particulates according to their aerodynamic diameter

Size Range	Diameter
PM10 (Thoracic Fraction)	Less or Equal than 10µm
PM2.5 (Respirable Fraction)	Less or Equal than 2.5µm
PM1	Less or Equal than 1µm
Ultrafine	Less or Equal than 0.1µm
PM10- PM2.5 (Coarse Fraction)	2.5 -10µm

Source: Mahadi, M. (2008)

4.2 Visualization of Tropospheric Monitoring Instrument (TROPOMI) Data

Understanding the effect of air pollution on public health is becoming more critical. Long-term exposure to certain gases, such as NO_2, O_3, SO_2, and HCHO, can cause adverse health effects such as bronchitis, respiratory infections, or asthma attacks, among other things. As a result, the World Health Organization has established both long-term and short-term CO, NO_2, O_3, SO_2, and HCHO exposure limits. Due to the greater levels of traffic-

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related air pollutants, which release CO, NO$_2$, O$_3$, SO$_2$, and HCHO, urban settings tend to have a higher concentration of air pollutants than rural locations. The research employed satellite data from the Sentinel-5P satellite's Tropospheric Monitoring Instrument (TROPOMI) for my thesis. The European Space Agency launched this satellite in 2022 to detect a variety of aerosols, including CO, NO$_2$, O$_3$, SO$_2$, and HCHO. This spectrometer has a time resolution of 7 km by 3.5 km and a spatial resolution of 1 day (although this was updated to 5.5 km by 3.5 km in 2019). GeoTIFF (.tif) or NetCDF (.nc) files are often used to store satellite remote sensing data. The research used the Copernicus Open Access Hub to get swaths of TROPOMI data that spanned the study region (Pabna, Bangladesh) as a series.NC files for my analysis. From the NetCDF data, the researchers utilized Arc-GIS to extract tropospheric NO$_2$, O$_3$, SO$_2$, and HCHO values, as well as longitude and latitude. The bulk of the tropospheric concentration of CO, NO$_2$, O$_3$, SO$_2$, and HCHO stays inside the planetary boundary layer and is essentially the product of human activity in metropolitan areas, even though this is considerably different from surface-level concentrations. The researchers constructed a data frame in R using the latitude, longitude, CO, NO$_2$, O$_3$, SO$_2$, and HCHO in mol/m^2 after extracting the data. Then I used the XY Table to Point tool in ArcGIS to convert the dataset to data points. This resulted in a feature class that allowed the CO, NO$_2$, O$_3$, SO$_2$, and HCHO data to be shown as points.
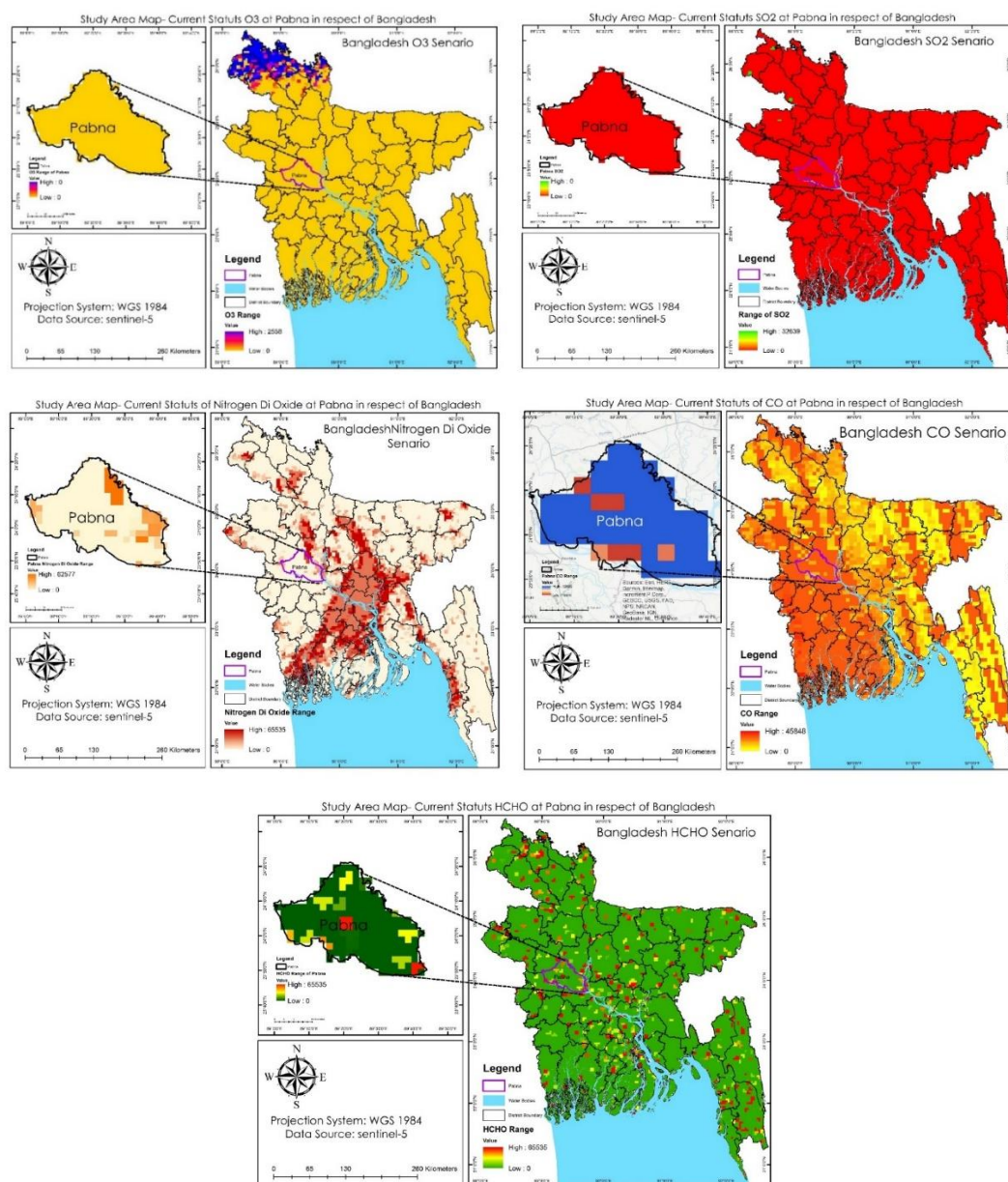

Figure 4: Current Status of O$_3$ (3a), So$_2$ (3b) No$_2$ (3c), CO (3d), and HCHO (3e) of Pabna Municipality

4.3 Demographics Information.

From the field survey, the demographic information is found in Table 3. Among the total 384 respondents, 23.40% were female and the rest were male. From the age information, it is seen that most of the respondents belong to the age group between 18 and 35 (47.7%). Moreover, 39.2% of respondents had an age group between 36 and 50 years old. 13.1% of respondents were in the age group of 50 and above. Most of the respondents were businessmen, and the percentage was 31.3%. Then 27.7% of respondents had a public service job. Moreover, the private service holders were 27.1%. Finally, 7.3% were from other professions (e.g., unemployed or students). Almost half of the respondents (48.63%) had an income level of between 0 and 20000 Tk. 28.57% of respondents had an income level of between 20000 and 40000 TK. The percentage of respondents having an income level of 40000–60000 was 19.14. The remaining 3.64% had an income level of 60,001 TK or above.

Table 4: Demographic Information of the respondents.

Variable Name	Variable Description	Variable Type or Outcomes	%	Mean
Socio-economic factors				
Gender	Respondent's gender			
Female			23.40	
Male			76.60	
Age group	Respondent's age			
18–35			47.7	
36–50			39.2	
50 above			13.1	
Employment status	Respondent's employment			
Public Service			27.7	
Housewife			6.6	
Private Service			27.1	
Business			31.3	
Other			7.3	
Income Range (In TK)	Respondent's income			
0-20000			48.63	
20000-40000			28.57	
4000-60000			19.16	
60000 above			3.64	
Problematic Sight				
Increase in respiratory disease	The literature shows that brick field emission has severely caused respiratory disease	Yes	80.11	
		No	19.89	
Agricultural production	Severe impact on agricultural production	Five-point Likert scale (1 = non-Problematic, 5 = Severe Problematic)		4.8
Impact on income	Negative Impact on Income	Five-point Likert scale (1 = non-Problematic, 5 = Severe Problematic)		4.1
Impact on land value	Degradation of land values	Five-point Likert scale (1 = non-Problematic, 5 = Severe Problematic))		3.4
Migration	Causes migration because of air pollution	Five-point Likert scale (1 = Not happening, 5 =Very Much Happening)		4.5
Soil Fatality	Degradation of Soil quality and fertility.	Five-point Likert scale (No effect, Adverse Effect=5)		4.2
Vegetation	Negative impact on vegetation.	Five-point Likert scale (No effect, Adverse Effect=5)		4.1
Aquaculture	Negative impact on aquaculture.	Five-point Likert scale (No effect, Adverse Effect=5)		4.1

Source: Field Survey, 2022

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4.4 Existing number of different types of particulates

Table 3 shows the combined data of all study locations and displays the number of different types of particulates in five stations of Pabna Municipality. The amount of 0.3µm Count/m3 of Library Bazar, Gachpara Crossing, Traffic Mor, Ononto Mor, and Main Bus Terminal are 107669, 580343, 501856, 255411, and 748091 respectively. The amount of 0.5µm Count/m3 of Library Bazar, Gachpara Crossing, Traffic Mor, Ononto Mor, and Main Bus Terminal are 58116, 52416, 51041, 53010, and 49458 respectively. The amounts of 1µm Count/m3 of Library Bazar, Gachpara Crossing, Traffic Mor, Ononto Mor, and Main Bus Terminal are 1424, 1198, 953, 1079, and 2197, respectively. The amounts of 3µm Count/m3 of those five points are 290, 191, 159, 106, and 686, respectively. Finally, the amounts of 5µm Count/m3 of those five points are 58, 56, 44, 37, and 120, respectively. The brickfields in Pabna are situated mainly in Wards No. 4, Word No. 3, and Word No. 6. Those wards are covered by the points of Library Bazar and Ononto Mor which have a heavy amount of particulate. The particulate matter groupings of PM2.5 and PM10 in the demeanor of Pabna have been gathered and thought about. The fundamental transport terminal is found as the exceptionally thought region for PM 2.5 and PM10. Different areas are likewise having high PM2.5 and PM10. It is found that the concentrations of PM 2.5 and PM10 in Pabna are higher than the surrounding air quality principles in Bangladesh. Block furnace emanation and long-range transport are the particulate matter sources that increase the particulate matter in Pabna. So, drives must be taken to control the PM outflow from block ovens and engine transport, which will have a positive effect on the air quality of Pabna. Accordingly, the opportunity has already come and gone to foster an air contamination decrease technique to shield individuals from the dangerous impacts emerging from raised barometrical follow metal levels through the orderly investigation of air contamination.

Table 5: Combined chart of all locations showing the number of different types of particulates.

| Place	Particulate				
	0.3µm Count/m^3	0.5µm Count/m^3	1µm Count/m^3	3µm Count/m^3	5µm Count/m^3
Library Bazar	107669	58116	1424	290	58
Gachpara Crossing	580343	52416	1198	191	56
Traffic Mor	501856	51041	953	159	44
Ononto Mor	255411	53010	1079	106	37
Main Bus Terminal	748091	49458	2197	686	120

Source: (Hasan *et al.*, 2016).

4.5 Consumer perception on brickfield impact determination

The impact of Brickfield's smoke emissions on the socioeconomic condition and human health in Pabna Municipality was assessed using five variables (increased respiratory disease, agricultural production, impact on income, impact on land value, and migration). Figure 4 visualizes the word-by-word consumer perception of the impact of Brickfield's smoke. A five-point Likert scale was established to find out the present impact of Brickfield's smoke. All the consumers of all the 15 words identify Brickfield's smoke as a problematic scenario. On average, over 70% or more consumers of Ward No. 1, 4, 7, 15), 60% or more consumers of Ward No. 3, 6, 8, 10, and 14), and 50% or more consumers of Ward No. 5, 11, 12, or 13 identify Brickfield's smoke as a severe problematic scenario. On average, over 25% or more consumers of Ward No. 5 (11), 15% or above, and consumers of Ward No. 3, 4, 6, 8, 10, 12, 13, 14) identify Brickfield's smoke as a problematic scenario. The rest of the consumers have Brickfield's smoke as a problematic scenario of less than 15%. Wards 1, 6, 7, 11, and 12 have more than 10% of the population.6% or above, consumers of Ward No. (3,5,8,10,13,14,15) identify Brickfield's smoke as Brickfield's smoke, a moderately problematic scenario. The rest of the consumers have Brickfield's smoke as a problematic scenario of less than 6%. Very few consumers identify Brickfield's smoking as having no problem or not a severe problem.

A maximum of the brickfields were located near the farming lands. Brickfields, according to 23% of respondents, have a negative impact on agricultural productivity. Half of the respondents expressed concern about a moderate impact, 27% expressed concern about a slight effect, and none expressed concern about no influence on agricultural productivity. Some residents who resided near the brick fields claimed that agricultural yields had decreased as a result of the brick fields' development. Due to the over-exploitation of their topsoil,

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agricultural fields have become unsuited for growing any crops. As a result, farmers are increasingly using large amounts of chemical fertilizers, which are damaging to the environment. The majority of respondents believe that the black smoke from brick kilns is to blame for crop loss. According to the study results, 68 percent of respondents said that brickfields had a negative impact on soil fertility.
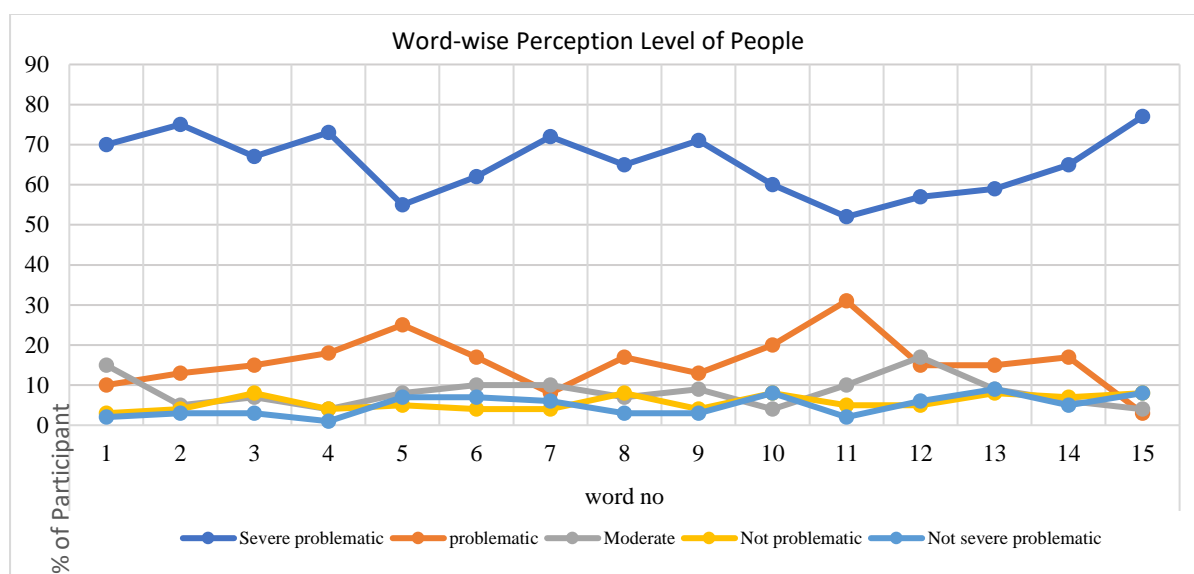
Source: Field Survey, 2022

Figure 5: Word-wise Percentage of Perception of participants on brickfield emission.

On the other hand, 13% of respondents said brickfields had a moderate influence on soil fertility, 6% said they had a slight effect, and 13% said they had no effect on soil fertility. Workers at the brick kilns remove dirt to make bricks. It has a direct influence on land deterioration and soil fertility. Topsoil removal has a detrimental influence on agricultural productivity and raises the expense of restoring the nutrients lost. The pH of the soil is reduced when it is burned, making it acidic. It has a significant influence on the physical, biological, and chemical aspects of soil, leading to a significant decrease in soil fertility and production.

Within a one-kilometer radius of the brick field, 48% of respondents said they saw negative impacts on vegetation, particularly fruits and vegetable plants. Residents living near brick fields stated that the brick fields had a moderate influence on vegetation; 23% said it had a slight effect, and 13% said it had no effect. Many locals said that plant buds, such as mango trees, litchi trees, blooming trees, and other trees, perished as a result of the black smoke from the brick kiln, and that plants did not develop correctly as a result. They also discovered that once brickfields were planted in the research region, fruit output decreased. Leaves were immediately seen to be coated in black smoke in several residential areas around brickfields.

The majority of respondents (36%) stated that "brickfields had no effect on fish production and aquatic plant production," while 17 percent stated that "brickfields had an adverse effect on fish production and aquatic plant production," 21 percent stated that "brickfields had a moderate effect on aquaculture," and 26 percent stated that "brickfields had minor effects on aquaculture after their establishment." The majority of the brickfields in Pabna Sadar Upazila's Hemayetpur, Dapunia, and Dogachi unions are situated near water sources. According to the responders, water contamination has impacted fish production in neighboring water bodies.

Table 6: Impact assessment on Agriculture

Effective Sector	Adverse Effect	Moderate Effect	Minor Effect	No effect
Soil Fatality	68%	13%	6%	13%
Agriculture Productivity	23%	50%	27%	N/A
Vegetation	48%	23%	16%	13%
Fish and Aquaculture	17%	21%	26%	36%

Source: Field Survey, 2022.

The Linear regression results (Table-7) show that the and p (sig. level) values for five imperial independent variables (increase of respiratory disease, agricultural production, impact on income, impact on land value, and migration) are =.002, p =.000; =.051, p =.000; =.075, p = 0.000; =.006, p =.002; and = 0.014, p =.000, respectively. The regression outcome shows that (an increase in respiratory disease, agricultural production, impact on income, impact on land value, and migration) have a significant influence on the level of problematic perception of consumers. The complete regression model was statistically significant with the F (3, 93) = 15.99, p 0.001, and adjusted = 0.035.

Table 7: Regression Model of impact on socio-economic and health conditions of consumers.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.260	.060		0.005	.000
Increase in respiratory disease	.008	.002	.002	0.014	.000
Agricultural production	.001	.002	.051	0.028	.000
Impact on income	.072	.009	.075	0.048	. 005
Impact on land value	.023	.017	.006	0.034	.002
Migration	.011	.007	.009	0.014	.000
Dependent Variable: Problematic Perception level of consumers, Adjusted R^2=0.035					

Source: Field Survey, 2022

4.6 Impact of Brickfield emission on Human Health

According to the findings of the field study, 12% of the total respondents in the study area are suffering from skin-related illnesses. Moreover, 12% of the total respondents in the study area are facing eye irritation. The percentage of people facing respiratory difficulties in the study area is 10. 10% of the total respondents in the study area are facing skin disease and eye irritation. Skin disease and respiratory illnesses in the study area were seen in 12% of the total respondents. Finally, 12% of the total respondents in the study area face eye frustration and respiratory illnesses. Only 8% of the total sample population is not affected by health problems due to brickfield emissions.

Table 8: Categories of illness found in respondents

Types of diseases	Percentage of affected respondents
Skin related illness	12
Eye irritation	12
Respiratory difficulties	10
Skin disease and Eye irritation	10
Skin disease and respiratory illnesses	12
Eye Frustration and respiratory illnesses	12
No problem	08
Total	100

Source: Field Survey, 2022

5. Conclusion

The study found that Pabna was severely impacted by the brick-field smoke emissions. Tropospheric Monitoring Instrument (TROPOMI) Data visualization shows that Pabna is suffering from air pollution. Brickfield emissions are one of the major causes of air pollution. The five-station data also supports the evidence that Pabna is severely vulnerable to air quality. The impact analysis indicates that most of the urban dwellers expressed their opinion that brick field smoke emissions cause severe damage and have a severe impact (increased respiratory disease, agricultural production, impact on income, impact on land value, and migration). Moreover, the regression analysis result shows that brick field smoke emissions have a severe impact on the increase in respiratory diseases, agricultural production, income, land value, and migration. However, no proper monitoring system for air quality measurement is taken at the municipality level. To improve the air quality and preserve the environment authority of Pabna needs to take the necessary action to measure the ambient air

quality regularly at the municipality level. The importance of brickfields cannot be denied. However, a proper monitoring system needs to be put in place to minimize the consequences of brickfield emissions. Though the modern kin system is being installed in many brickfields, some brickfields still avoid modern technology. Therefore, the monitoring system needs to be improved. By this, the impact of Brickfields' smoke emissions on socio-economic conditions and human health can be minimized. Participatory approaches can be taken to solve the problem, and these findings would help to find a better solution to improve the air quality of Pabna.

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